I, the undersigned, who have prepared English translation which is attached herewith, hereby declare that the aforementioned translation is true and correct translation of officially certified copy of the Korean Patent Application No. 2000-11533 filed on March 8, 2000.

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[Abstract of the Disclosure]

[Abstract]

The present invention relates to a reflective-transmissive complex type thin film transistor liquid crystal display in which liquid crystal films of a transmissive region and a reflective region are different in thickness so as to adjust a phase of polarized light at each of pixel portions constituting a screen. For this, in a step of forming a gate electrode or a source/drain electrode, a transparent electrode of a pixel electrode and a transparent electrode pattern made of a metal such as chrome are first formed. When a protection insulating layer is formed on a thin film transistor, an upper side of a transparent electrode pattern is exposed by a patterning process. While a reflection electrode is formed, a transparent electrode pattern is also exposed and then an overlying opaque metal layer is removed at the transparent electrode pattern.

Accordingly, the phase of the polarized light is adjusted to increase the amount of emitted light in one region while the amount of the emitted light is fixed at another region and to enhance entire screen luminance and contrast.

[Typical Figure]

FIG. 5

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[Specification]

[Title of the Invention]

A REFLECTIVE-TRANSMISSIVE COMPLEX TYPE TFT LCD AND A METHOD OF FORMING IT

[Brief Description of the Drawings]

FIG. 1 and FIG. 2 are a top plan view and a cross-sectional view at a pixel portion of a substrate of a thin film transistor according to an example of a conventional reflective-transmissive complex type thin film transistor liquid crystal display.

FIG. 3 is a concept diagram showing a sectional structure of a liquid crystal display panel and a phase shift of light at a reflection region and a transmission region so as to describe conventional problems.

FIG. 4 is a top plan view showing a pixel portion of a lower substrate and a plan side of a pad portion according to an embodiment of the present invention.

FIG. 5 is a cross-sectional view, taken along a line A-A, showing a section of a lower substrate pixel portion.

*Explanation of the signs that are the main part of the drawings

10 : substrate	11 : gate pattern
13 : gate insulating layer	15 : semiconductor layer
17 : ohmic contact layer	19 : source/drain electrode
21 : transparent electrode pattern	23 : organic insulating layer
25 : reflection layer pattern	27 : transmission region

31, 33 : polarization plate
35, 37 : phase difference plate
39 : liquid crystal layer
41 : reflection plate
51 : transparent electrode layer
61 : chromic layer

[Detailed Description of the Invention]

[Object of the Invention]

[Field of the Invention and Prior Art related to the Invention]

The present invention relates to a reflective-transmissive complex type thin film transistor liquid crystal display and, more particularly, to a reflective-transmissive complex type thin film transistor liquid crystal display in which additional reflective and transmissive layers constituting a pixel electrode are formed to occupy a predetermined region of a pixel.

A thin film transistor liquid crystal display is representative of an active matrix type liquid crystal display and uses active nonlinear devices. In the thin film transistor liquid crystal display, unlike a semiconductor device where transistor elements are formed on a semiconductor substrate, a transistor is formed on a glass substrate. Therefore, the thin film transistor liquid crystal display has the following characters. The thin film transistor liquid crystal display is classified into a top gate type one and a bottom gate type one depending on whether when a transistor is formed, a gate is formed on or under a channel. Further, the thin film transistor liquid crystal display is classified into an amorphous silicon type one and an active silicon type one depending on whether a semiconductor constituting a channel is made of amorphous material or polysilicon.

In addition, a liquid crystal display including a thin film transistor liquid crystal display according to the character that it cannot make a light is classified into a transmissive one and a reflective one. In the transmissive

liquid crystal display, an independent light source is installed at a rear side of a panel and while a light passes a liquid crystal panel, a user recognizes images. In the reflective liquid crystal display, while a light source installed at a front side of a panel or an external light is reflected, user recognizes images of a liquid crystal panel.

A patterning process is performed again to form a pixel electrode on the protection layer. In case of a reflective LCD, the pixel electrode is formed on an upper portion of a pixel by stacking aluminum using a sputtering technique and a photolithographic process and an etching process, and is electrically connected to a source of a transistor through a contact. The pixel electrode acts as a reflective layer. Since a light reaches user's eyes through the pixel electrode, the pixel electrode of a backlight or transmissive LCD is made of transparent ITO (indium tin oxide), IZO (indium zinc oxide), and so forth (fifth mask).

A reflective LCD is mainly used in an apparatus for minimizing power consumption such as a timepiece or a calculator in early stage. However, a transmissive LCD is mainly used in a notebook computer, particularly, a TFT-LCD requiring a wide screen and high quality. Sharp Inc. already introduced a reflective-transmissive complex type LCD which can secure a visibility fitted for the use environment even if a peripheral brightness is varied.

FIG. 1 and FIG. 2 are a top plan view and a cross-sectional view at a pixel portion of a substrate of a thin film transistor according to an example of a conventional reflective-transmissive complex type thin film transistor liquid crystal display. In the introduced reflective-transmissive complex type thin film transistor LCD, a pixel electrode pattern is formed as a transparent electrode layer by means of a sputtering manner when a pixel electrode is formed on an organic insulating layer 23 while an electrode of a conventional TFT side substrate 10 is formed. After a metal layer (i.e.,

reflective layer) made of aluminum or chrome is formed thereon by means of the sputtering manner, a desired reflective layer pattern is formed by means of a mask process (i.e., a photolithographic process and an etching process). As a result, a pixel electrode outside region, a transparent region, and a reflective region are formed. In the pixel electrode outside region, the pixel electrode including the reflective layer 25 or the transparent electrode 21 does not remain on the organic insulating layer 23. In the transmissive region 27, only the transparent electrode 21 remains. In the reflective region, the reflective layer 25 remains on the transparent electrode 21. The transparent region 27 is a window conceptively and thus may be called a transparent window. FIG. 1 is a cross-sectional view of a TFT side substrate at a pixel portion according to an example of the conventional reflective-transmissive complex type TFT-LCD. Here the transparent electrode 21 is formed prior to formation of the organic insulating layer 23.

In a panel of the conventional reflective-transmissive complex type TFT-LCD, liquid crystal layers or cell gaps of transmissive and reflective regions of each pixel are substantially equal in thickness to each other. However, in view of a light phase at a TN type liquid crystal cell adopted in most TFT-LCD, it is impossible to simultaneously obtain a maximal luminance at a transparent mode and a reflective mode in case that the liquid crystal layers are equal in thickness to each other.

FIG. 3 is a concept diagram showing a cross structure of a liquid crystal display panel and a phase shift of light at a reflective region and a transmissive region in order to explain conventional problems. In a reflective region, a light does not pass under a reflective layer 41. Therefore, a backlight or a phase different plate is meaningless and will not be described in further detail. A polarization plate 31 of a panel upper portion (front side) is disposed to pass only light elements having a phase vibrating left and right in this figure. A lower side (rear side) polarization plate 33 of a

transmissive region is installed to pass light elements having a phase vertically vibrating to the figure. Pivots of phase difference plates 35 and 37 are perpendicular to each other in an internal side of the polarization plate. The liquid crystal layer 39 controls property and thickness of the material, so that a phase shift on a light passage becomes λ/4. Further, liquid crystal layers in both regions are substantially equal in thickness to each other.

In ON state where a voltage is commonly applied to panel upper and lower electrodes in the two regions, there is no light from the panel. In this case, since the liquid crystal layer is arranged to be not distorted but parallel, the phase is not shifted. Accordingly, the thickness of the liquid crystal layer is not significant. However, in OFF state where a voltage is not applied to the panel upper and lower electrodes, the light running from the panel to the outside must be in a phase where it is rotated counter-clockwise shortly before passing the upper phase difference pate (λ/4 plate) so as to maximize the amount of the light from the panel. On the other hand, the phase shift of the light passing a conventionally designed liquid crystal layer is λ/4 (45°). To maximize the amount of the emitted light, the light starting to run from the pixel electrode (e.g., the light reflected from a reflective layer in a reflective mode) must be present at a phase where it vertically vibrates to the figure.

However, as shown in FIG. 2, if the polarization plate and the phase difference plate are arranged on a structure of a polarization plate 31, a phase difference plate 35, a liquid crystal layer 39, and a (-) phase difference plate 37, and a polarization plate 33 which are associated with polarization, analysis, and phase shift of the light from the front side, the light starting to run from the pixel electrode, i.e., the light passing the transparent electrode 43 is in the phase where it is rotated clockwise in order to avoid an emitted light of the panel. As a result, in the case that the thickness of the liquid crystal layer is conventionally designed, if the phase shift of the passing

light is a thickness corresponding to λ/4, it has a vertically rotated phase, not a phase where it is rotated counter-clockwise shortly before passing the upper phase difference plate and it has a phase rotated counter-clockwise before passing the polarization plate. Thus, the amount of the emitted light has a phase difference of λ/4 (45°) with respect to a polarized light passing the polarization plate without loss, so that the light amount is reduced to be half of the maximal amount.

Particularly, there is a need for complementing means for avoiding loss of light amount in view of the fact that the reflective-transmissive TFT-LCD has an acute problem associated with the luminance.

[Technical Object of the Invention]

Therefore, it is an object of the invention to provide a novel reflective-transmissive complex type thin film transistor liquid crystal display which can overcome the problem that a maximal luminance can be obtained at a transmission region as well as a reflection region of a conventional reflective-transmissive complex type thin film transistor liquid crystal display, and a fabricating method thereof.

[Construction of the Invention]

In accordance with an embodiment, a reflective-transmissive complex type thin film transistor liquid crystal display device includes a glass substrate, a thin film transistor which is formed on the substrate, a first pixel electrode which is formed on the substrate and is electrically connected to a drain electrode of the thin film transistor, an insulating layer which is formed on the first pixel electrode and the thin film transistor and has a hole formed to expose the first pixel electrode, and a second pixel electrode which is formed on the insulating layer to expose the first pixel electrode and is electrically connected to the drain electrode.

In the present invention, the first pixel electrode becomes a transparent electrode and the second pixel electrode becomes a reflection electrode, and vice versa.

The insulating layer is made of an organic material and has a thickness such that a Δnd value of a liquid crystal layer of the same thickness becomes 1/4 wavelength. The first pixel electrode is patterned with the same material as the gate electrode of the thin film transistor at the same time and a layer of the material includes chrome or tungsten molybdenum (MoW) stacked on the transparent electrode layer. A contact hole is formed on the drain electrode in the insulating layer, so that the second pixel electrode contacts the drain electrode through the contact hole and contacts the first pixel electrode through the hole.

In accordance with another embodiment, a method of forming a reflective-transmissive complex type liquid crystal display device includes a step of forming a thin film transistor and a first pixel electrode on a glass substrate, a step of stacking and patterning an insulating layer on a substrate including the thin film transistor and the first pixel electrode pattern to expose the first pixel electrode, and a steps of stacking and patterning a second pixel electrode layer on the patterned insulating layer to form a second pixel electrode and to expose the first pixel electrode pattern.

In the present invention, the first pixel electrode pattern includes a transparent electrode layer and is simultaneously formed by a patterning manner so as to be interconnected with the same material as the drain electrode of the thin film transistor. The first pixel electrode pattern is made of a metal-capped transparent electrode layer, after exposing the first pixel electrode while forming the second pixel electrode, further comprising a step of etching capping metal of the first pixel electrode by using the second pixel electrode and the patterned insulating layer as an etching mask to be removed. The capped insulating layer is made of chrome, the reflection

metal layer is made of aluminum, and the transparent metal layer is made of ITO or IZO. The first pixel electrode pattern is made of the same material as the gate electrode of the thin film transistor at the same time and a layer of the material includes chrome or tungsten molybdenum (MoW) stacked on the transparent electrode layer. The second pixel electrode is made of aluminum to expose the transparent electrode of the first pixel electrode pattern at the same time when the second pixel electrode is patterned.

The present invention will now be described more fully hereinafter with reference to attached drawings, wherein the same numerals denote the same components.

FIG. 4 is a top plan view showing a pixel portion of a lower substrate and a plan side of a pad portion according to an embodiment of the present invention. A reflection electrode and a transmission electrode pattern are interchangeable. In a boundary of the reflection electrode and the transmission electrode, two electrode layers are directly electrically connected to each other or are disposed with intermediary metal interposed therebetween to be electrically connected to each other.

FIG. 5 is a cross-sectional view, taken along a line A-A, showing a section of a lower substrate pixel portion. An example of forming this structure is now described. A dual layer including a transparent electrode layer 51 and a chrome layer 61 is stacked on a glass substrate 10 and is patterned to form a gate electrode, a gate line, a gate pad, and a transparent electrode pattern. A transparent electrode layer 41 is made of ITO or IZO by means of a sputtering manner. The chrome layer 51 is also formed by means of the sputtering manner. The transparent electrode layer 41 is electrically separated from the gate pattern. A gate insulating layer 13 is stacked by means of CVD and is patterned to cap a gate electrode and a gate line with the use of silicon nitride or silicon oxide.

An amorphous silicon semiconductor layer 15 and an impurity-doped

amorphous silicon ohmic contact layer 17 are stacked by means of a CVD (chemical vapour deposition) manner and are patterned to make an active region remain. The active region becomes a source/drain region and a channel region of a thin film transistor. A layer of metal such as aluminum is stacked by means of a sputtering manner and is patterned to form a source/drain electrode 19, a data line, and a pad. Using the source/drain electrode 19 as an etching mask, the ohmic contact layer 17 is etched to be removed.

Under the state that the thin film transistor and the transparent electrode are formed on the glass substrate 10, an organic insulating layer 13 is stacked and holes are formed in order to expose the drain electrode and the transparent electrode pattern. Using only a photoresist layer, the organic insulating layer 13 is patterned only by means of a photolithographic process. A thickness of the organic insulating layer 13 is set so that a value Δnd of a liquid crystal layer of a corresponding thickness is 1/4 wavelength. At this time, the transparent pattern is almost exposed. Afterwards, a reflection layer is formed of metal such as aluminum and is patterned to form a reflection electrode 25.

The reflection electrode 25 is electrically connected to the drain electrode and a partial region of the transparent electrode pattern through the holes, and the transparent electrode pattern is almost exposed. Under this state, the chrome layer 61 disposed on the transparent electrode layer 51 is etched to be removed. The chrome layer 61 disposed at a part where the transparent electrode pattern and the reflection electrode contact with each other is protected by an aluminum mask to remain, preventing the transparent electrode constituting the transparent electrode from directly contacting the aluminum. The drain electrode and the transparent electrode pattern are connected through the reflection electrode.

According to the foregoing example, the transparent electrode pattern

is made of the same layer as the source/drain electrode without being formed together with the gate electrode. In this case, the gate electrode is made of aluminum, the source/drain electrode layer is made of a transparent electrode and chrome which are sequentially stacked, and the reflection electrode is made of chrome or aluminum. Further, it may be patterned so as to connect the drain electrode to the transparent electrode pattern.

In the case where the organic insulating layer is used, a pre-designed concave-convex side is used, not a plan surface of the insulating layer, to act as a condensing lens. In the case where an opposite angle and a tilted angle of an opposite side in the substrate are not considered, a thickness of the liquid crystal layer in the transmission region is conventionally two times larger than that of the liquid crystal layer in the reflection region. In spite of less than two times, it is effective that the liquid crystal display in the transmission region is thicker. In the case where the treatment of the opposite layer can be different in both regions, the thickness of the liquid crystal layers may be different.

In the example that the transparent electrode and the reflection electrode are interchanged in position, the transparent electrode is an single layer made of ITO or IZO and the reflection layer is a dual layer including a gate electrode layer made of aluminum and a source/drain electrode layer made of chrome.

[Effect of the Invention]

In a reflective-transmissive complex type thin film transistor liquid crystal display device according to the present invention, a liquid crystal layer in a reflection region is different in thickness from a liquid crystal layer in a transmission region. Therefore, a phase of polarized light is controlled to increase the amount of emitted light in one region upon the state that the amount is fixed in another region and to enhance general

screen luminance and contrast.

[Scope of the Claim]

[Claim 1]

A reflective-transmissive complex type thin film transistor liquid crystal display device comprising:

a glass substrate;

a thin film transistor which is formed on the substrate;

a first pixel electrode which is formed on the substrate and is electrically connected to a drain electrode of the thin film transistor;

an insulating layer which is formed on the first pixel electrode and the thin film transistor and has a hole formed to expose the first pixel electrode; and

a second pixel electrode which is formed on the insulating layer to expose the first pixel electrode and is electrically connected to the drain electrode.

[Claim 2]

The device of Claim 1, wherein the first pixel electrode is made of a transparent electrode pattern and the second pixel electrode is made of a reflection electrode.

[Claim 3]

The device of Claim 2, wherein the insulating layer is made of an organic material and has a thickness such that a Δnd value of a liquid crystal layer of the same thickness becomes 1/4 wavelength.

[Claim 4]

The device of Claim 2 or Claim 3, wherein the first pixel electrode is patterned with the same material as the gate electrode of the thin film transistor at the same time and a layer of the material includes chrome or tungsten molybdenum (MoW) stacked on the transparent electrode layer.

[Claim 5]

The device of Claim 2 or Claim 3, wherein a contact hole is formed on the drain electrode in the insulating layer, so that the second pixel electrode contacts the drain electrode through the contact hole and contacts the first pixel electrode through the hole.

[Claim 6]

A method of forming a reflective-transmissive complex type liquid crystal display device, comprising:

a step of forming a thin film transistor and a first pixel electrode on a glass substrate;

a step of stacking and patterning an insulating layer on a substrate including the thin film transistor and the first pixel electrode pattern to expose the first pixel electrode; and

a steps of stacking and patterning a second pixel electrode layer on the patterned insulating layer to form a second pixel electrode and to expose the first pixel electrode pattern.

[Claim 7]

The method of Claim 6, wherein the first pixel electrode pattern includes a transparent electrode layer and is simultaneously formed by a patterning manner so as to be interconnected with the same material as the drain electrode of the thin film transistor.

[Claim 8]

The method of Claim 7, wherein the first pixel electrode pattern is made of a metal-capped transparent electrode layer, after exposing the first pixel electrode while forming the second pixel electrode, further comprising a step of etching capping metal of the first pixel electrode by using the second pixel electrode and the patterned insulating layer as an etching mask to be removed.

[Claim 9]

The method of Claim 8, wherein the capped insulating layer is made of chrome, the reflection metal layer is made of aluminum, and the transparent metal layer is made of ITO or IZO.

[Claim 10]

The method of Claim 6, wherein the first pixel electrode pattern is made of the same material as the gate electrode of the thin film transistor at the same time and a layer of the material includes chrome or tungsten molybdenum (MoW) stacked on the transparent electrode layer; and

wherein the second pixel electrode is made of aluminum to expose the transparent electrode of the first pixel electrode pattern at the same time when the second pixel electrode is patterned.

Fig. 1

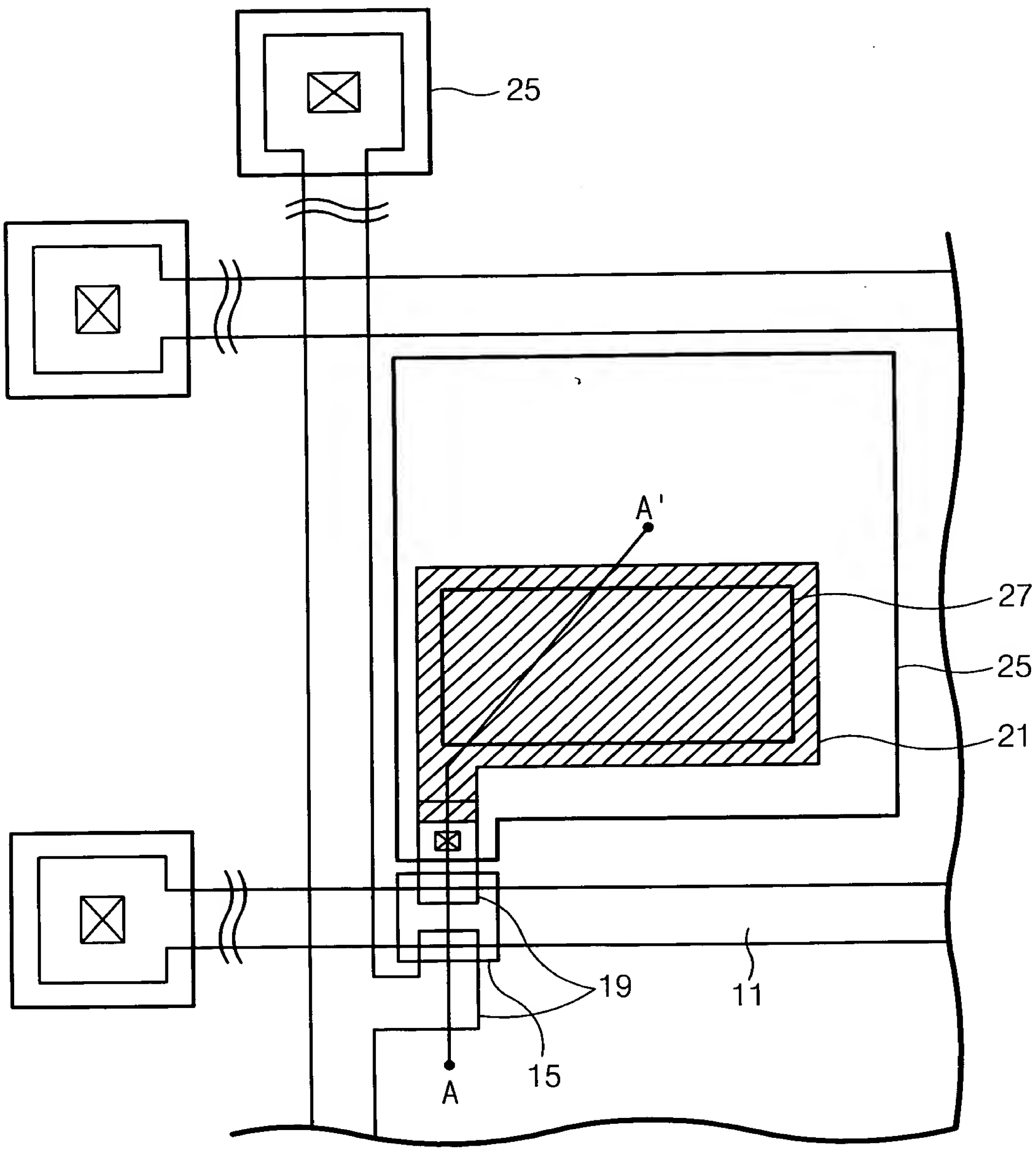
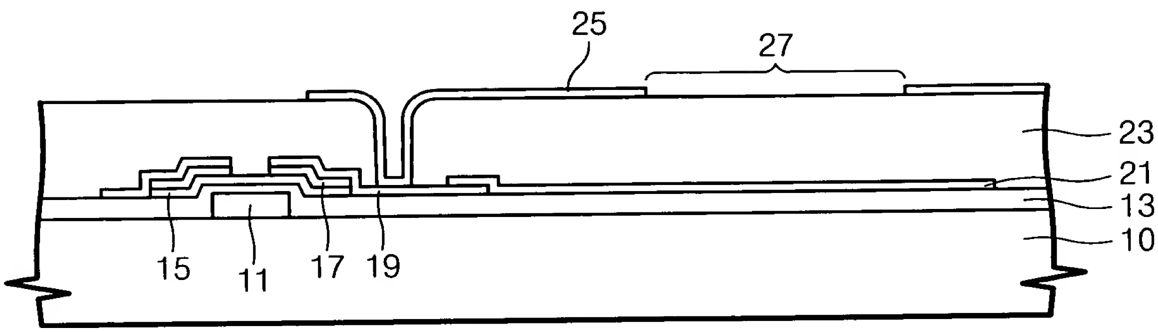


Fig. 2



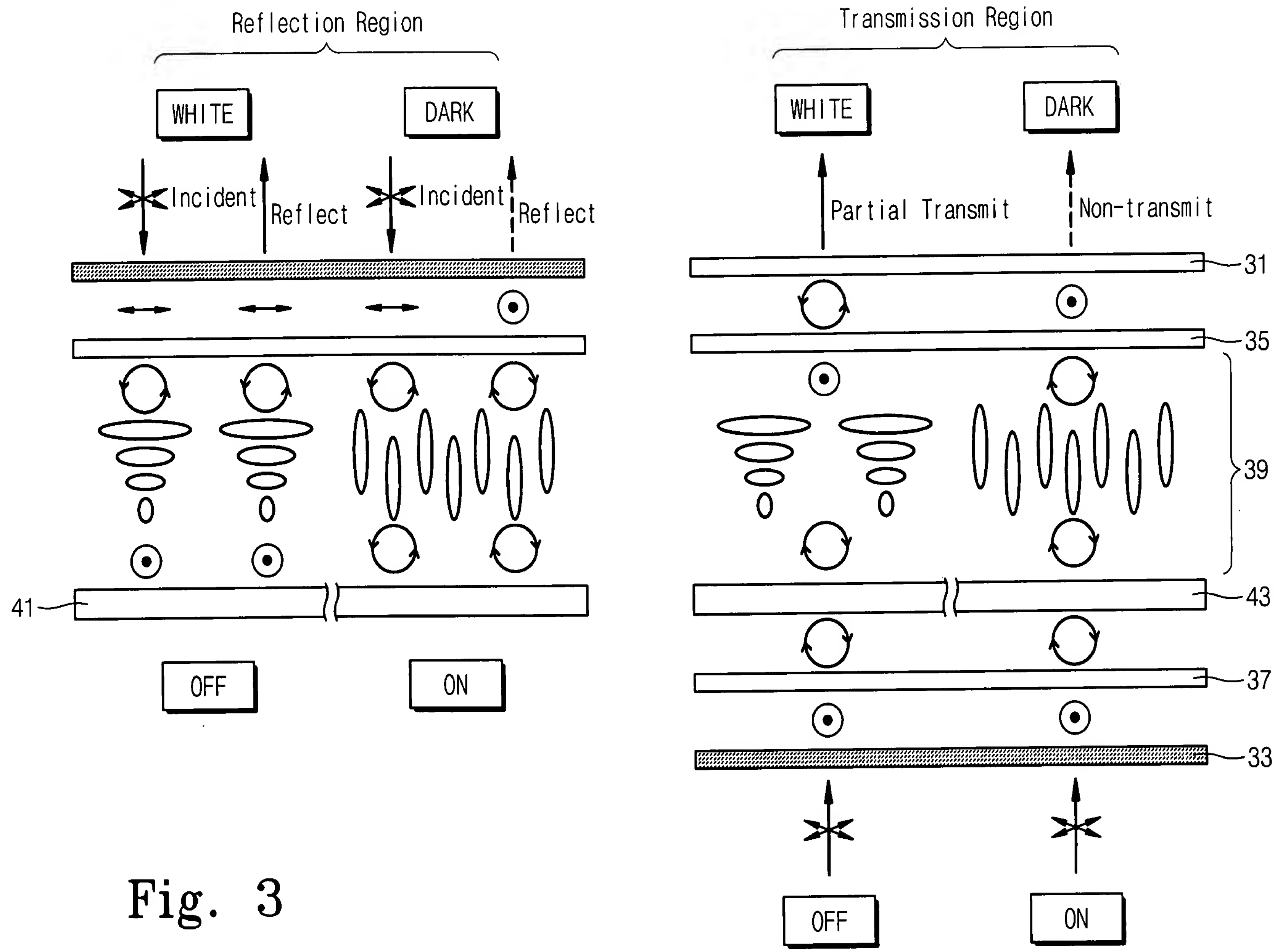

Reflection Region
WHITE
DARK
Incident
Reflect
Incident
Reflect
41
OFF
ON
Transmission Region
WHITE
DARK
Partial Transmit
Non-transmit
31
35
39
43
37
33
OFF
ON

Fig. 3

Fig. 4

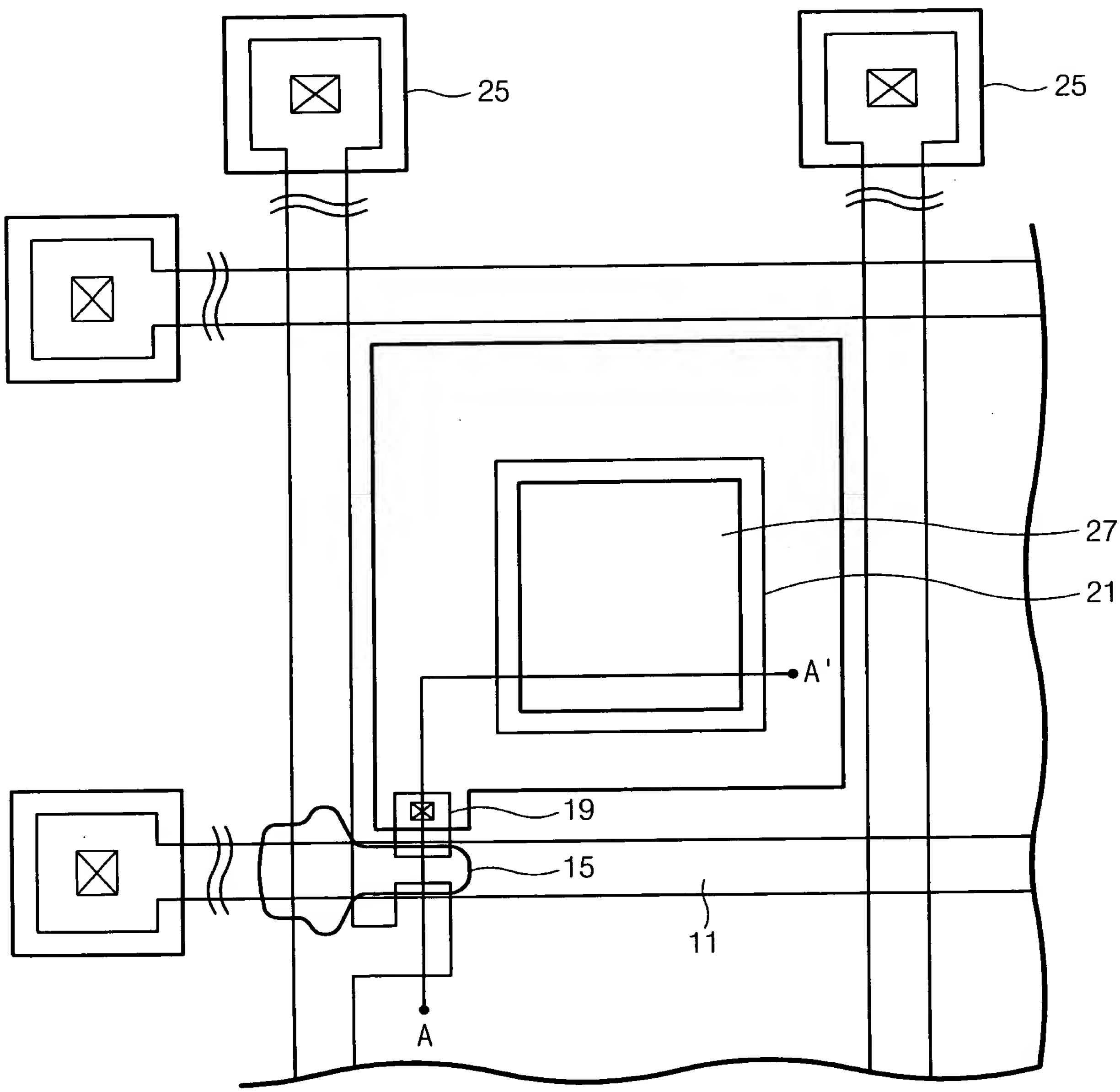


Fig. 5